Catalysis of Biodegradable Polymers with Immobilized Enzymes

Beamline: U10B

Technique: Infrared microspectroscopy

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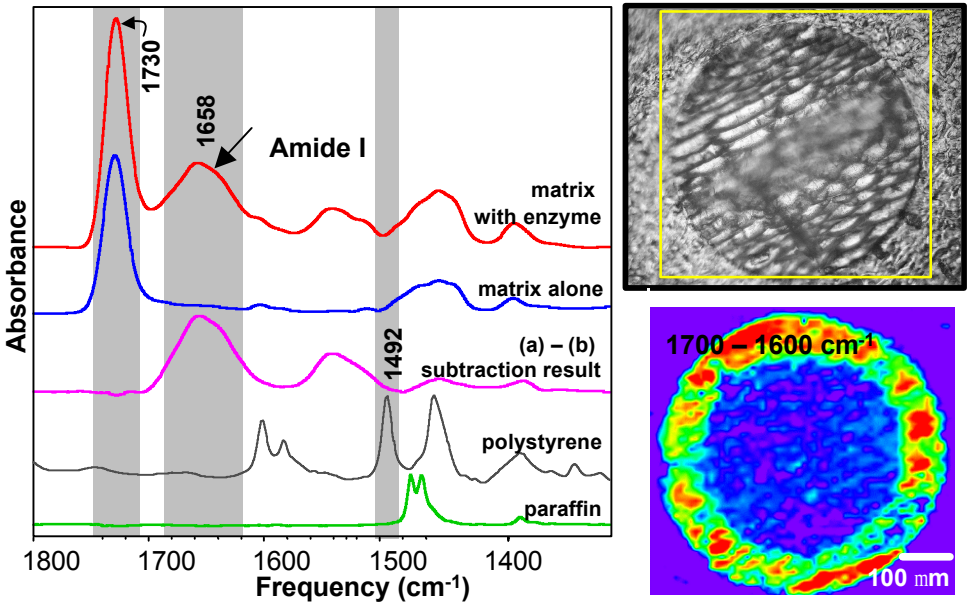
Motivation: Enzymes catalyze many reactions with high specificity, speed, and yield. However, in order to be useful as industrial biocatalysts, improvements in enzyme stability, activity, and recovery are necessary. Traditionally, these obstacles have been addressed by the immobilization of enzymes on polymer or ceramic matrices. A critical parameter in the performance of an immobilized enzyme is the spatial distribution of the enzyme and substrate within a macroporous resin, which can be determined with IRMS.



(Left) Infrared spectra illustrating unique features for the matrix (1730 cm^{-1}), enzyme (1658 cm^{-1}), substrate (1492 cm^{-1}). (Right top) Light microscope image of the bead cross-section. (Right bottom) Infrared image of the protein distribution throughout the bead.

Results: The distribution of an enzyme (Lipase B from *Candida antarctica*, CALB) immobilized within a macroporous polymer matrix (polymethyl methacrylate) was imaged with IRMS at 10 μm resolution. The beads of this catalyst (Novozym 435) were cut into thin sections (12 μm). SIRMS imaging of these thin sections revealed that the enzyme is localized in an external shell of the bead with a thickness of 80 - 100 μm. Unlike CALB, polystyrene molecules of similar molecular weight diffuse easily throughout Novozym 435 beads. Scanning Electron Micrograph images of the Novozym 435 beads showed that the average pore size is 10 times larger than CALB or polystyrene molecules, implying that there is no physical barrier to enzyme or substrate diffusion throughout the bead. Thus, the difference between polystyrene and enzyme diffusivity suggests that protein-matrix and protein-protein interactions govern the distribution of the enzyme within the macroporous resin.